THE NON-DESCRIPTIVE PALAEONTOLOGY OF THE SOWERBYS' *MINERAL CONCHOLOGY*

BY

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CONTENTS

SYNOPSIS

Analysis of the classic descriptive work on British fossils, *Mineral Conchology* by J. and J. de C. Sowerby, published 1812–1846, shows a surprising number of small but significant passages foreshadowing lines of research and development carried out subsequently as the science of palaeontology and its appropriate technology developed, up to the present day. Included are some internal structures and their significance for foraminifera, cephalopoda, barnacles and brachiopoda; comparisons of fossils with their living analogues and reconstruction of the palaeoenvironments; the significance of some different types of fossils for stratigraphy; and a very early speculation on the evidence of fossils, for different, earlier positions of the Earth's poles. Finally a comment of James Sowerby on structures which are sometimes preserved to be seen more clearly in fossils than in recent examples, is justified by reference to the palaeobotany of a century later.

1. INTRODUCTION

The *Mineral Conchology* of the Sowerbys occupies a very special place in British Palaeontology. Although produced from 1812 to 1846, with the majority of text and plates before 1830, its minutely accurate coloured illustrations and descriptive comments have ensured its working value, as opposed to historical interest, to the present day. This is in spite of the pioneer nature of much of the contents, and of the uneven geological documentation resulting from the gradual development of stratigraphy (and its terminology) during the years of publication.

The *Journal of the Society for the Bibliography of Natural History* recently devoted an entire number (1974 : **6** (6)) to the Sowerbys and their publications, especially the *Mineral Conchology*, and to the contents of the very interesting and meticulous studies therein I have nothing to add. The present paper endeavours to deal with another aspect of the Sowerbys' work which has long interested me. Given that the attempt to describe and illustrate British fossils was a likely development from James Sowerby's descriptive works on living plants and minerals, how far, if at all, are modern developments in palaeontology foreshadowed in the work? How much did James Sowerby, and his son James de Carle, think of their fossils as remains of once-living creatures; how far did they realize the special considerations which apply to a fossil, as opposed to a Recent, shell? It must be realized that any such thoughts would be made in a 'pre-evolutionary' mental climate, that the geological time-factor would be, at best, very dimly sensed, and that any ideas found will be expressed in literary and imprecise terms, without any of the later terminologies which have grown to fit what are now subjects of study in their own right.

Inevitably, any compilation of such evidence will be capable of arrangement in various ways. That adopted here is to take those aspects arising directly from the fundamental descriptive nature of the *Mineral Conchology*, first, and to proceed from these to the writers' more philosophic speculations. The quotations which in this paper are ascribed to James Sowerby, or to James de Carle Sowerby, are on the basis of attribution of text and plates to the former up to the end of part 65 (in volume 4), and thereafter to the latter. Cleevely (1974 : 446) in discussing this boundary, has drawn attention to a letter of J. de C. Sowerby (1839) stating that much of the text (as opposed to plates) in the earlier parts was prepared by J. de C. and G. B. Sowerby and, indeed, the work as a whole seems very much to have been a family production.

2. INTERNAL STRUCTURES AND MICROSTRUCTURE

Devoted as it was to British fossil shells, the detailed external form and hinge-structures of molluscs form a great part of the work. But fossils are more usually filled with hard and intractable matrix ; the Sowerbys, operating before the days of thin-sections, serial sections and X-rays, and with only the minority of hollow or easily excavatable specimens and the occasional lapidary's polished surface, nevertheless show an early realization of the essential importance of internal structures.

(a) *Cephalopoda* (*and Foraminifera*)

From the first part of Volume I James Sowerby showed an interest in recording the position of the siphuncle, an internal shelly tube of hydrostatic significance found in shelled cephalopods. Siphuncles are usually peripheral in ammonites and central in nautiloids. J. Sowerby was careful to indicate its position in the aberrant, uncoiled or turricone members of the former (*Hamites*, *Turrilites* ; I, 135, 169, 170), and to mention it where it could be seen, in many species of the latter. J. de C. Sowerby, towards the end of the work, gave a summary of the form of the septa and position of the siphuncle in London Clay nautili (VII, 35, pl. 627), showing the change in position of the siphuncle during the growth of *Nautilus imperialis*.

This interest of the Sowerbys extended to all fossils referred to the Cephalopoda. At that time the shelled foraminifera were regarded as minute nautili. This ascription was made from the shells and not from the living animals, the foraminifera being of course much lower in the scale of life than the Cephalopoda (Mollusca) to which *Nautilus* belongs. D'Orbigny (1826) whilst recognizing the distinctive shelly characters of foraminifera, still grouped them as a section of the Cephalopoda, and it was not until after the recognition of living species as Protozoa (Dujardin 1835) that they became classified in their own right and not as minute Cephalopoda

(Mollusca). Hence in 1816 James Sowerby, describing a Cretaceous foraminifer as *Nautilus comptoni* (probably a *Lenticulina* sp.), wrote : 'I am sorry not to be able to find the siphuncle, but I suspect it is at the outer extremity. In all my specimens, which is seldomer the case in Nautili than in Ammonites, it was obscure : one had a little break where I expected it, but I could not say it was there : – it must therefore be left for further research' (II, 45, 46). The siphuncle is exclusively a cephalopod structure, and so, naturally, he could not find it.

This foraminifer seems to have troubled the Sowerbys. Perhaps they realized that whilst its characters conformed to those used in the then current taxonomy, it (and its kind) were nevertheless in some way different, a feeling not unknown to many taxonomists. Thus in 1826 J. de C. Sowerby, discussing nummulites, wrote : 'The Nummulariae are supposed to belong to the same division of the Order Cephalopoda as Nautilus, Spirula, etc. . . .. Nautilus Comptoni Tab. 121 belongs to this genus.' But a couple of pages later he added a footnote 'N. Comptoni, tab. 121, has only one or two whorls and about eight septa, and is one of the most remote species from Nummularia of Authors' (VI, 74, 76).

(b) *Brachiopoda*

Although Brachiopoda have long been recognized as a distinct and more primitive phylum than the Mollusca, their usual double-valved, shelly remains have some general similarity to those of bivalved molluscs, and the Sowerbys described many brachiopods in the *Mineral Conchology*. Many, though by no means all, brachiopods have an internal structure, the brachidium, composed of thin shelly ribbons inside the valves and often of considerable complexity in form ; these structures are of the greatest value in classification. In fossils, usually filled solid with hard matrix or mineral infilling, the brachidia are difficult of access ; serial sections, and chemical or mechanical dissection and clearance, are the usual means of revealing them today. In hollow or friable fossils, broken specimens sometimes reveal them, usually damaged, and often crusted with calcite or other mineral, and rather more frequently, the hinge-structures to which they are attached. Internal moulds in clear calcite may also sometimes show internal structures by translucency.

Such specimens were carefully figured by the Sowerbys when available : I, pl. 15 ; III, pls 265, 268 ; V, pls 435, 502 ; VI, pl. 535 ; VII, pl. 616. Of *Terebratula plicatilis* (now *Cretirhynchia*) James Sowerby wrote that it occurred 'sometimes in such a state as to separate from the chalk, and show something of the interior construction, which is very desirable in this division of shells, as it is often very remarkable' (II, 37). But in addition there are a few brachiopods whose internal structures were dealt with by the Sowerbys in more detail.

James Sowerby, in two short communications to the Linnean Society in 1814–15 (Sowerby 1819), drew attention to the spiral brachidia in certain Carboniferous species, indicating that these occurred not merely in the externally transverse species typical of spiriferids, but in other, terebratuliform, shells. This work is referred to in the *Mineral Conchology* (II, 41, footnote), and this subject is returned to in IV, pl. 376, p. 105, by J. de C. Sowerby (see Cleevely 1974 : 444–446 on attribution of authorship here) : 'In general appearance it does not agree with most of the species of the Genus Spirifer, but approaches nearer to the smooth Terebratulae ; its having a perforated beak, and little or no hinge-line, still further distinguish it ; but the actual existence of spiral appendages seems to confirm it a Spirifer, unless its combining the characters of both Genera should render it advisable to construct a new genus of it. But as the appendages within the Terebratulae are very variable, it will be well to wait until more of them are known.' The 'terebratuliform' species described is now *Composita ambigua*, a member of the Athyridacea ; this was an early recognition of the occurrence of shelly spiral lophophore supports in several different families of the Brachiopoda.

James Sowerby also interested himself in the brachial supports of *Magas pumilus*, an Upper Cretaceous brachiopod with a somewhat unusual pattern of brachial support. *Magas* often occurs in, and is filled with, soft chalk which can easily be removed. It must be remembered that at this period even the more usual types of brachial structures in present-day shells were rarities, and little understood. Sowerby recognized the unusual nature of *Magas* from a broken specimen and described it as follows : 'In the middle of the shell rises a thin longitudinal septum reaching from one valve to the other ; the upper part of it arches over to the hinge, the front of it is perpendicular, on each side are two shelf-like appendages, one over the other, the upper ones united by slender processes to the hinge. [Upside-down by later conventional orientation.] I know of but one species, some variation in these particulars may be expected in others, but the general structure is sufficiently remarkable to warrant the establishment of the Genus' (II, 39). This was the first described genus of these 'long-looped' brachiopods. Plate 119 gives a good, enlarged and recognizable figure, even though knowledge was so elementary that he could write : '. . . to which valve this septum is attached I have not been able to ascertain, because I could not open the shell without breaking it'. He also noted the distinctive shell-punctation under magnification (II, 40). In a footnote (p. 39) he added 'it were much to be wished that some person would publish an account of the curious internal appendages of these shells' (though it is not clear if he means species cited in an erroneous comparison, or brachiopoda in general). And, indeed, the study of brachiopod brachial structures now has a large intrinsic literature, and has thrown much light on the variety and inter-relationships of these brachiopods, as well as on past anatomy.

Finally in 1826 J. de C. Sowerby described a Lower Cretaceous brachiopod as *Terebratula truncata* (VI, 71). This name was preoccupied for a living species of Lamarck's, and the fossil is now known as *Gemmarcula aurea* Elliott. Sowerby wrote : 'Were it not for the aperture in the beak and the internal structure, which is fortunately well preserved, it might be taken for a Spirifer.' (A continuation of the elder Sowerby's thoughts on the relations of external form and internal structure.) In Plate 537 J. de C. Sowerby illustrates this species. Because of the 'hollow' preservation, this was the species which I used (Elliott 1947) to demonstrate the full series of ontogenetic changes in a fossil terebratellacean for comparison with similar growth-stages in living genera. Sowerby's figured enlarged shell with loop is recognizable as the growth-stage which I termed 'campagiform' ; it is of an example with septum and descending branches intact but the ascending portion of the loop broken, as sometimes occurs. When one measures the size of the little shell from which the enlargement is taken (Sowerby's middle two figures of four collectively forming fig. 3), the size (transverse diameter) is exactly that given by me for that growth-stage (Elliott 1947 : 151). No better example could be given of the Sowerbys' amazing accuracy in drawing things understood but very little at the time, though there are many examples as good.

(c) *Barnacles* (*Cirripedes*)

In figuring the shelly remains of these Crustacea from the Pleistocene Crags of East Anglia, James Sowerby commented : 'The inside projections and pores at the narrowish base are exposed in the lower figures 3 and 4 ; in one of them which is very thick, the bottom pores are elongated. Perhaps it will become of use to notice these parts as the progress of the yet infant knowledge of organic remains will point out' (I, 194). Although barnacles are not favourites of palaeontologists, yet this prediction, too, has come true, and the monograph of Davadie (1963) deals in great detail with the internal structures and pores of such fossils.

From all these examples it is clear that, in spite of limitations of knowledge and the absence of techniques now taken for granted, the Sowerbys showed a remarkable perception of avenues of future research on the less obvious or concealed characters of their fossils.

(d) *Serpulids*

In describing the Jurassic *Serpula tricarinata* (VI, 226) J. de C. Sowerby wrote 'Among the squamae . . . or between the lines of growth . . . there are frequently minute pores or short tubes, but whether formed by the animal of the Serpula or some minute one is not easily discovered.' Scrutton (1975) records this as probably the first notice of what he described in detail as a hydroid-serpulid symbiosis, ranging from the Mesozoic to the present day.

3. COMPARISONS WITH LIVING FORMS AND PALAEOENVIRONMENTS

As conchologists, the Sowerbys were familiar with much general information on the structures, and to a lesser extent on the habits and environments of living mollusca and other shelled organisms. It is therefore not surprising to find frequent comparisons, and some reconstruction, with their fossils.

James Sowerby compared the operculum of a London Clay serpulid with those of Recent forms (a subject returned to by J. de C. Sowerby, VII, pl. 634, together with their varying objects of attachment), the variation in Wealden *Viviparus* with that to be found in living freshwater snails, and a comparison of Coal Measure mussels with living freshwater mussels (I, 73, 77, 84). All these are lines of investigation followed in more recent times (Wrigley 1951, Prashad 1928, Eagar 1948). In comparing the living *Teredo*, or shipworm mollusc, with fossil remains (I, 229–234), he remarked : 'I have not detected the spatulate valves' (I, 234). These pallets, as they are now called, are of much classificatory value and a considerable literature exists on them. They may be isolated by washing from incoherent rocks (cf. Stinton 1957), or occasionally, with exceptional preservation, revealed in hard rocks by sectioning (Elliott 1963). Wrigley (1930, 1939) ascribed some but not all of Sowerby's figures to *Teredina personata* Lamarck, which he states does not have pallets.

In dealing with attached (sessile) molluscs J. Sowerby commented on Recent cemented *Ostrea* and *Anomia* showing the ribbing of *Pecten* to which they were attached (II, 22, footnote). Of oysters in general he wrote (III, 66) : 'Oysters and some other common shells are the most puzzling, because they admit of such extensive variation that, although there are certainly many species among them, the greatest discernment meets continually with stumbling blocks, while attempting to distinguish them from one another, or the recent from those of ancient times.' Many palaeontologists subsequently must have echoed the spirit of these words ; it is to be hoped that the admirable *Treatise* volume on oysters (Stenzel 1971) will provide a basis for determination hitherto in great part lacking.

Classification apart, J. de C. Sowerby gives an early but excellent consideration of evidence to be obtained from fossil oysters. Writing of oysters attached to the cast of a Jurassic ammonite (V, 22) he said : '. . . there does not appear to be space enough between them and the stoney cast for any shell, it must have been thin, and is perhaps of such a texture as does not permit it to be readily distinguished from the Oyster ; or we must conclude that the Ammonite was in a fossil state before the Oysters existed, but had not been removed far from its original station, before it was again buried to form along with the Oysters the index to another epocha.' Examination of a large ammonite in the British Museum (Natural History) from this level, the Corallian Sands (Upper Oxfordian) of Wiltshire–Berkshire, in the preservation depicted by Sowerby (articulated casts of the chambers) showed small oysters attached to the body-chamber, which was a matrix cast. It was not possible visually to be sure whether the oysters were attached to shell (surviving where they covered it) or direct to the cast. Dr M. K. Howarth thought the shell of the body-chamber on an ammonite of that size would be thick enough to show, and it does seem likely that the oysters were attached to the cast, which must thus have been re-exposed on the sea floor after burial and some diagenesis, after a geologically short interval. It shows considerable perception on the part of J. de C. Sowerby to have evaluated these possibilities.

This realization of the varying conditions under which organisms could be buried together for fossilization is again well shown in J. de C. Sowerby's discussion of the mollusca from the 'White Sand connected with the Lower Freshwater [or rather, perhaps, the so-called Upper Marine] Formation in the Hordwell Cliff' in Hampshire (VI, 61, 62). 'We have therefore either a mixture of Marine and Freshwater shells in a bed hitherto thought by us to contain only Freshwater ones, or we are mistaken in drawing conclusions from analogy without sufficient examination.' (Then follows an analysis of the fauna as then known and named, with comparisons with living analogues and their environments.) He continued : 'All these shells still leave us, therefore, in doubt. But what does the Serpula prove? No Serpula is known to live in fresh water, and the one we have along with these Mussels is too tender to have been removed far ; so if the other shells belong to fresh water, they must have been brought down by a river into the sea ; but they are extremely well preserved, and many as tender as the Serpula, which makes us rather incline to the option that they are all Marine, at least those which occur in the same stratum.'

'That river shells should be washed down to the coast and mix with marine ones is probable : even large masses or islands, consisting of decayed vegetable matter with the shelly remains of animals that lived in lakes, may by floods be carried into rivers, and by them down to the sea, and be deposited upon the ordinary sediment in the bed of the ocean. The analogy of the various shells in the formation we allude to, rather favours this hypothesis. We leave it to geologists to compare a number of facts, respecting situation and many other circumstances, to determine the question.'

The bed under discussion later came to be known as the 'Crocodile Bed' in the Lower Headon Beds (Upper Eocene) of Hordle Cliff (the modern spelling). It became famous for its vertebrate remains, excavated for the Marchioness of Hastings (Hastings 1852, Edwards 1970). An account of the stratigraphic succession as now visible is that of Edwards (1971), who also provided a very brief account of the depositional environment (Edwards, in Cray 1973). Dr Edwards interprets the fauna of terrestrial mammals, freshwater reptiles and fishes, and some estuarine molluscs as indicating deposition, at the mouth of a river, in an environment locally brackish (low saline) : a full account is pending. Daley (1972) has analysed the invertebrate assemblages and their palaeoenvironmental significance in the Bembridge Marls of the same area. Of particular interest is his account of mixtures of *Viviparus* (freshwater) and serpulids (low-salinity). These he ascribes to introduction of serpulid larvae and subsequent rapid breeding, following saline invasion of certain coastal freshwater environments. On a return to freshwater conditions the serpulids were buried as whole 'knots' or growths, or, if scouring occurred, mixed with freshwater shells. Sowerby's comments are seen thus to be in accord with modern researches, and well ahead of his time. He subsequently described the Hordwell serpulid (VI, 202).

A further example of his speculation on palaeoenvironments occurred in discussing the bivalve *Panopaea* (now *Panomya*) from the British Pleistocene. He ascribed observed dwarfing of shell-size and shell-thickening to environmental conditions ; shallow water or freshwater dilution, rather than climatic change (VII, 2).

He also (VII, 74, 77) discussed the anatomy of Recent Razor-shells before describing fossil species. These are specialized, elongate, burrowing bivalves all of very similar habitats, with hinges greatly reduced in complexity ; in *Solen* the hinge-detail is more simple than in *Ensis*, and Sowerby suggested that this was in some way due to the life-habits of the two differing. Dr N. Holme, of the Marine Biological Association, Plymouth (personal communication), suggests that there is nothing in the depth-range of *Solen* which could correlate with the difference in structure, and that this character is related to phylogeny. However, it is possible that an investigation of the burrowing habits and of the grain-size of preferred sediment, for these two genera, might yield some evidence on differences between them, to which hinge-structure might be an adaption. *Solen* also has a much wider present-day geographical distribution than has *Ensis*.

Like many palaeontologists, and especially considering the period in which they worked, the Sowerbys were dependent upon published zoological accounts of the fleshy anatomy of some of the organisms on which they worked. Thus James Sowerby mentioned Cuvier's account of the anatomy of *Lingula*, a genus familiar to palaeontologists for its common occurrence and persistence through much of Phanerozoic time, but now a tropical and sub-tropical brachiopod and thus in his day a rarity in European collections. Sowerby wrote laconically (I, 56): 'He found that it has two hearts.' Cuvier (1802) was in error over this anatomical identification, though in his defence it must be said that the current authoritative account describes the 'heart' in *Lingula* as normally a very simple and inconspicuous thickening – 'contractile appendage' – of the central mid-dorsal channel of the so-called circulatory system, and that *Crania* is said to have several of these (Williams & Rowell 1965). But James Sowerby consulted the standard anatomical account of his day, and quoted Cuvier correctly, even if (we may surmise) with some doubt.

4. STRATIGRAPHY AND PALAEOGEOGRAPHY

British stratigraphy underwent much of its early development during the period covered by the publication-years of the *Mineral Conchology*. James Sowerby was the engraver for William Smith's classic *Strata identified by organized fossils*, etc. (Smith 1816–19), sold from (amongst other addresses) Sowerby's publishing home, and perhaps because of this direct references to stratigraphy are few.

James Sowerby (II, 212), dealing with Jurassic gastropods from equivalent strata (Bajocian), in the Jurassic of southern England and northern France, wrote: 'It appears very remarkable to me, that strata agreeing in their composition so closely should produce several shells resembling each other, but, as far as I have hitherto learnt, none are precisely the same. I wish to instigate further research. It is a circumstance corresponding with provincial differences among mankind; whether such differences among shells should be considered as specific, may remain a question.' The gastropods considered, '*Trochus* spp.', are pleurotomariids, abundant at this horizon and a very variable group both in space and time. Irrespective of later developments in both exact stratal correlation, and in the taxonomy of the shells, the comments of Sowerby show an early appreciation of the difficulties of the taxonomic handling of regional differences in closely related taxa.

In dealing with the London Clay, he wrote (IV, 77) of its conspicuous nautili: 'It is remarkable that the prevailing species of Nautilus, found at the depth of about 60 feet, in the Regent's Canal, near the White Conduit House at Islington, in 1815, and also in Hyde Park, should prove different from that found at Highgate, and upon the Isle of Sheepey, yet numerous specimens prove that fact.' This is a very early attempt (1822) at indicating faunal divisions within the London Clay, a comparison of lower with higher levels within the formation, well in advance of Wetherell's classic paper (1836), a system later worked out in great detail by Wrigley (1924, 1940) and currently under review by the Tertiary Research Group.

Finally, written in the year of his death, there is James Sowerby's prophetic passage, including later-established views on the variable stratigraphic value of fossils, but rising above this to an early appreciation of one of the great problems in earth science : 'May not the several formations that lie in strata, or coats, over the nucleus of the earth, have successive zones replete with the fossil remains of the animals etc. peculiar to them, besides such as are universally distributed through them, which zones might be discovered by a diligent comparison of the fossils of different countries, and indicate the probable position of the poles previously to the destruction of life in those strata, for the order and perfection of many of the remains seem to indicate that they are not far removed from their original sites' (IV, 63). The occurrence of well-preserved remains of tropical and subtropical life in what are now temperate or cool latitudes (cf. Arkell 1935) has exercised many minds, and the reverse may be found in the tropics. Changes in distribution of land and sea, continental drift and its crustal mechanisms, changes in solar radiation or in the tilt of the earth and, currently, changes in global diameter *pari passu* with crustal drift have all been invoked without, so far, decisive conviction. It is to the lasting credit of the artist, engraver and natural history illustrator James Sowerby that he saw above the careful perfection of his illustrating, for which he is now celebrated, to the tantalizing and curious mysteries of the earth's history.

5. CONCLUSION

It will, I hope, be realized from what is written above that the Sowerbys, father and son, in their careful descriptions and illustrations of British fossils, saw well beyond this routine work into the realms of thought now elevated into separate studies. Yet the mere handling of material objects itself gives the intelligent worker unexpected vision. I quote from James Sowerby (II, 53) writing of a worn and imperfect specimen of a fossil nautiloid (ever one of his favourites) : 'How admirable is it that Nature allows us so much distinction in specimens that have undergone such vicissitudes, while we are often puzzled with very perfect recent ones! It is truly useful . . . and thus will the recent species become more easy to our exercised faculties.' His son, James de Carle Sowerby, was later to illustrate the famous fossil fruits of the London Clay for Bowerbank (1840). Reid & Chandler (1933), in one of the most fascinating pieces of research ever produced, revised this flora in the light of nearly a century of knowledge of both recent and fossil tropical botany. They wrote (p. 29) : '. . . in fossilized fruits and seeds the fusion of successive coats, which in life may appear complete, tends to be dissolved by the processes of maceration and decay, the separation being yet further emphasized by the intercalation of layers or films of matrix. Consequently the structure as well as the succession of coats can often be more readily observed and more completely studied in the fossil than in the living' ; and on p. 30 (referring again to this phenomenon) : 'This was particularly well exemplified in specimens of *Tricarpellites communis* when compared with *Canarium*. One of the most remarkable of the coats of *T. communis* is that described by Bowerbank as a "beautifully reticulated layer". The term exactly describes it ; and in the fossil it is most conspicuous. It forms the middle coat of the endocarp. Although we had traced in the living all the other coats seen in the fossil, we could find no sign of this, which in the fossil separates freely from the others. It was only after many weeks of maceration in nitric acid that we were able at last adequately to expose the coat.'

I need give no further illustration of the Sowerbys' excellence in their chosen field, over and above the descriptive work for which they are famous.

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Top : Plate 537 of the *Mineral Conchology*, showing various fossil brachiopods, natural size. The two middle figures of the four comprising figure 3 (top centre) show an immature example of '*Terebratula truncata* J. de C. Sowerby' and an enlarged line drawing of its internal structure.

Bottom : Enlargement of the two middle figures of the composite figure 3, above, to show Sowerby's careful depiction of the slightly broken immature brachial structures within the hollow shell-cavity.